Bachelor of Software Engineering - Game Programming

GD2P02 – Physics Programming

Dynamics

Overview

- Dynamics
  - Force and Motion
  - Friction
  - Tension
  - Momentum
  - Impulse
  - Energy

Dynamics

- Dynamics is concerned with the study of forces.
- Mostly related to Newton's second law of motion.

$$F = m*a$$

  - Linear dynamics
    - Motion in a line
  - Rotational dynamics
    - Rotating objects, motion in a curved path

Force and Motion

- Force starts the motion based on the second law of Newton's laws of motion. (F = m*a)

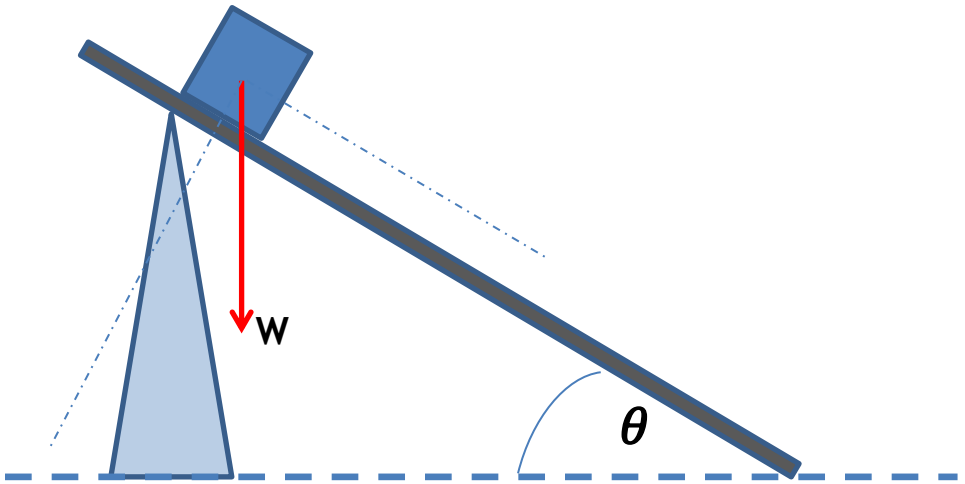


Fig 1: Inclined plane, force and motion.

Friction: Normal Force

- Newton's third law predicts that any force to a surface is opposed and balanced with another force.
- Action meets reaction.
- Therefore, the downward force of the weight must be opposed by an equal and opposite force coming from the surface.

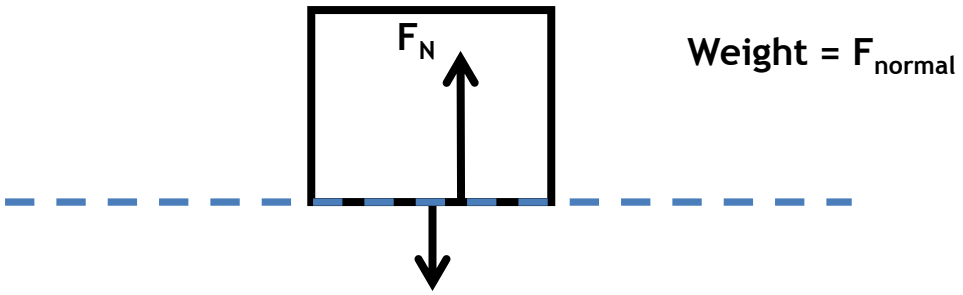


Fig 2: Balanced forces on an object on the ground.

Friction: Static Friction

- Static Friction: f_s

$$f_s = \mu_s * F_N$$

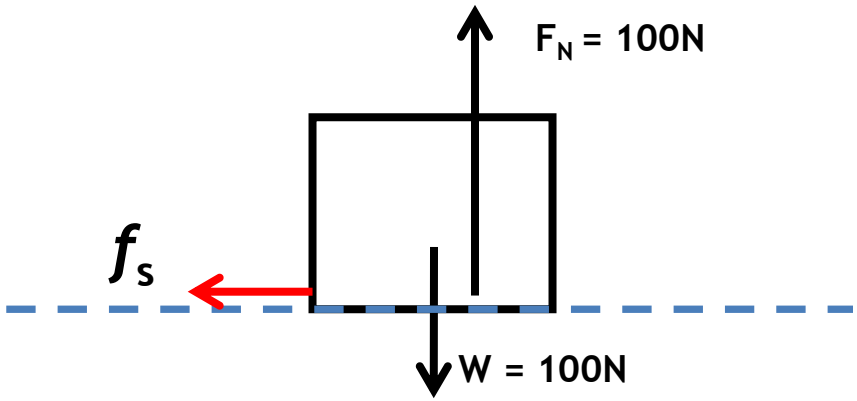
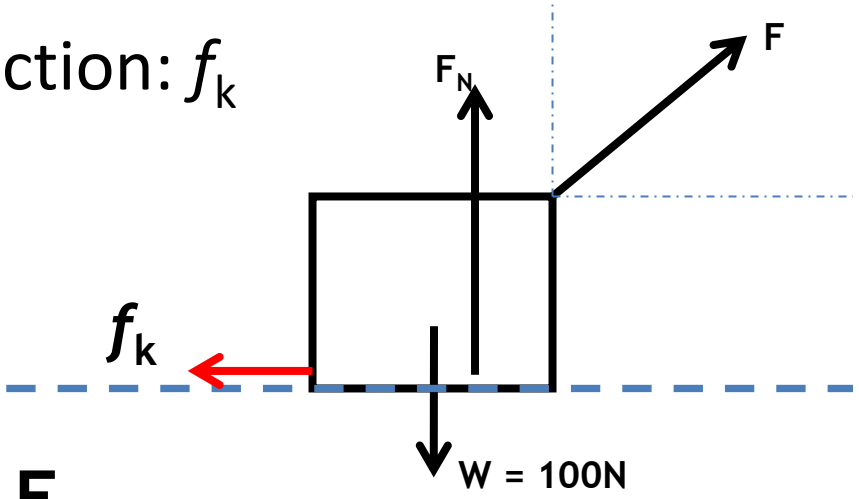


Fig 3: Force of static friction.

- μ_s - friction coefficient; a measure of the degree to which the two materials which are in contact will resist the tendency to slide past one another.

Friction: Kinetic Friction

- Kinetic Friction: f_k



$$f_k = \mu_k * F_N$$

Fig 4: Force of static friction.

- F_N is the reaction of the surface.
- In this case F_N will be F_y - W.
- Kinetic friction is directly proportional to F_N.

Tension

- Tension, *T*, is the pulling force.
- When a length of rope having negligible mass is under tension, both ends of the rope pull with equal force in opposite directions.

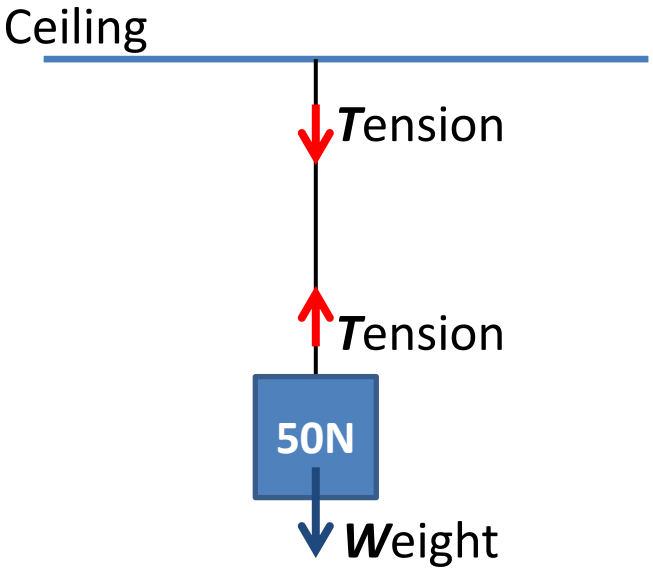


Fig 5: Tension on the rope.

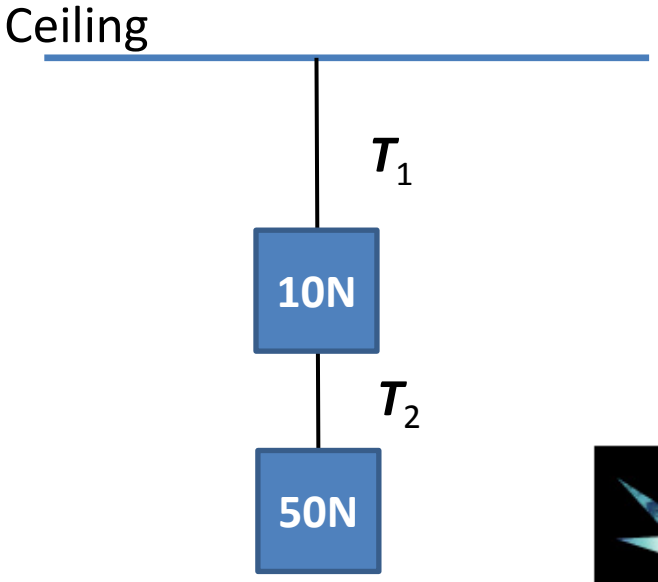


Fig 6: Tension example.

Tension and Pulleys

- When a rope of negligible mass passes through a massless, frictionless pulley, the tension of the rope will be the same on each side of the pulley.

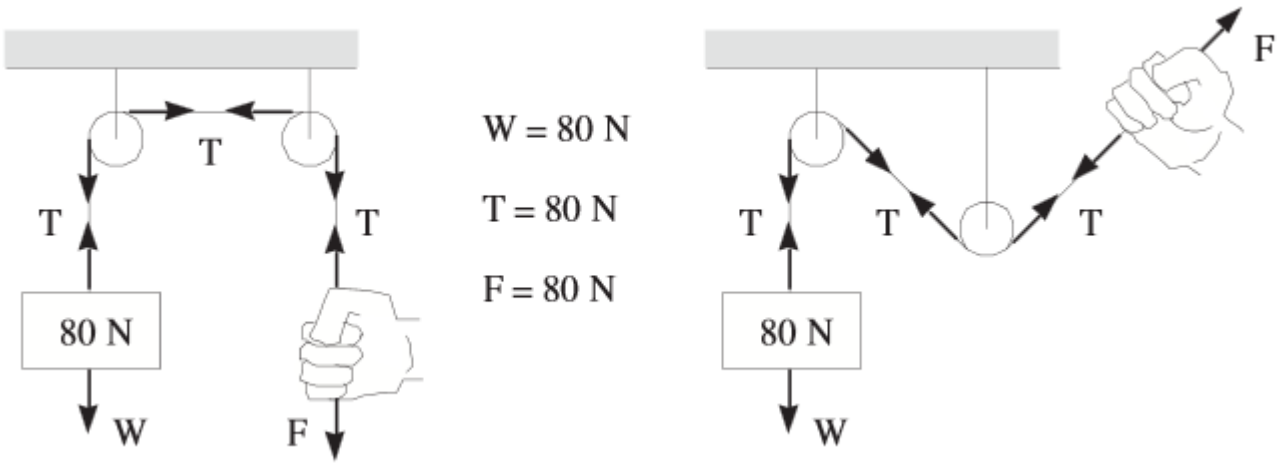


Fig 7: Tension and pulleys.

Momentum

- For a collision between two objects, that total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision.

- For example:
  - Momentum lost by one object is gained by the other!

- Collision of objects: Conserves momentum.

Mass and Momentum

- Momentum: Mass in motion…
  - All objects have mass.
  - If a mass is moving, it has momentum.
    - Mass in motion!
  - How much momentum?
    - How much stuff (mass)?
    - How fast is the stuff moving?
  - Momentum depends on mass and velocity.

    Momentum = mass x velocity

    $p = mv$
  - Unit: $kgms^{-1}$
    - Momentum is a vector quantity…

Impulse

- Impulse is change in momentum.
    - $\Delta p = p_f - p_i$

- Impulse: $\Delta p = m(v_f - v_i)$
    - $F = ma$
    - $F = m * ((\Delta v)/ \Delta t)$
    - $F * \Delta t = m * \Delta v$

Energy

- Kinetic energy: energy of a body or a system with respect to motion
- Potential energy: energy of a body or a system stored because of it position
  - If an objects energy is small enough over multiple frames, it needs to be put to sleep.
    - Small enough energy, sleep the object.

Kinetic Energy

- Linear Kinetic Energy:

$$E_k = (1/2)mv_f^2$$

Where:

- m = Mass of the object
- v_f = Speed of the object
- E_k = kinetic energy (scalar)

– Kinetic energy: the amount of work required to set a body in motion.

– Unit: Joule

Potential Energy

- Potential Energy:

$$E_p = mgh$$

Where:

- m = Mass of the object
- g = gravity
- h = height of the object
- E_p = potential energy (scalar)

– Potential energy: the amount of work required to get a body in that position.

– Unit: Joule

Summary

- Dynamics
  - Force and Motion
  - Friction
  - Tension
  - Momentum
  - Impulse
  - Energy